Folded tub for a heat exchanger and method of making sam

FIELD OF THE INVENTION

The present invention relates generally to heat exchangers for motor vehicles and, more specifically, to a folded tube and method of making same for a heat exchanger, such as an condenser, in a motor vehicle.

DESCRIPTION OF THE RELATED ART

It is known to provide a tube for a heat exchanger such as a condenser in an air conditioning system of a motor vehicle. The tube typically carries a first fluid medium in contact with its interior while a second fluid medium contacts its exterior. Typically, the first fluid medium is a liquid or a two-phase liquid and gas mixture and the second fluid medium is a gas. Where a temperature difference exists between the first and second fluid mediums, heat will be transferred between the two via heat conductive walls of the tube.

In addition, it is known to provide multi-port tubes for condensers in an air conditioning system in a vehicle. Such tubes often have small hydraulic diameter ports for heat transfer enhancement. In addition, the interior port walls provide strength to withstand the high-pressure requirements of the refrigerants in such systems. A known method of forming a tube for a heat exchanger is to extrude the tube in an extrusion process. Particularly with multi-port type exchangers, the extruded tube has become the 'primary choice' for motor vehicle condensers when certain performance levels are required. Extruded tubes of the multi-port type have advantages such as being virtually leak-free and being a structurally integrated part of the condenser. However, these sort of extruded tubes have the disadvantages of requiring internal dimensions that must have wide tolerances, in order to keep the extrusion dies life span at a reasonable level to be practical, i.e. tighter tolerances generally reduce die life, whereas the requirement of wider tolerances of most extruded tubes of this nature means that

there is increased material usage, and, the extruded tubes, therefore, are relatively expensive to produce.

Yet another known method of forming a tube for a heat exchanger is to provide a flat, elongated sheet with lugs and the ends of the sheet are folded to form the tube. The ends of the tube are then brazed. An example of such a tube is disclosed in U.S. Pat. No. 5,386,629 issued on February 7, 1995, Ouchi et al. In this patent, the tube may have flow paths between the lugs. However, the quality of the folded tube to header joints is related to how small the outside web shoulders can be with the smaller the better to prevent leakage.

US Patent 6,241,012 issued on June 5, 2001, Yu et al, disclosed a folded tube and method for making such for a heat exchanger with a base and top and at least an internal web. The folded tube has very small outside web shoulder radii and a plurality of fluid parts.

US Patent 6,209,202 issued on April 3, 2001, Rhodes et al, discloses a folded tube and a method of making the same, including a base, an opposing top, and sides interposed between including at least one of the base and the top having at least one internal web. Compression leads to multiple parts. Column 3, lines 35-40 and Figure 4 show an arcuate shaped end feature.

One attempt to overcome the problems of the prior art include designs for air condition applications wherein one end of tube is 'locked' by binding a number of layers of sheets of material together to lock the tube. By binding, for example, 5 layers of sheet together, to lock the tube end, a very 'strong' or 'solid' positive lock of the condenser tube is achieved prior to brazing: however, such a layering and positive lock also imposes a very rigid relationship between the total tube height, and sheet gauge (tube wall thickness): the total tube height can be more than about five times wall thickness in some cases.

As described above, attempts to overcome problems in condenser brazing with flat tubes have often led to solutions that impose very rigid relationships

between total tube height and sheet gauge. However, in those 'solutions' several other problems have been discovered : tube gauge might be not optimized since this rigid relationship provides that once tube height is determined, tube gauge is determined also, but not fully due to the structural requirement; this relationship does not allow the use of potential future stronger materials, since reducing the gauge to meet the same structural requirement would not be possible due to the rigid height gauge relationship; and the reduced flexibility in tube design for different applications is less advantageous due to the fact that heat exchanger tube design must consider both heat transfer and airside pressure drop.

For exchangers with core depths greater than or equal to 25 millimeters, the higher air pressure drop involved with the increased core depth, would mean it would be optimal to have lesser tube height. On the other hand, for cores of short depth less than or equal to 22 millimeters, because less airside pressure drop is involved, tube height can be increased. The present invention overcomes many of the problems described above.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide a multi-port folded tube for a heat exchanger, and, in particular, a multi-port condenser tube and a method of making thereof. It is further object of the present invention to provide a folded tube and method of making a multi-port folded tube for a heat exchanger wherein at least one tube locking feature is included.

It is a further object of the present invention to provide a folded tube formed into multi-port tube wherein tighter tolerance and use of material occurs due to the tube locking, and, preferably, end-locking design of the present invention. It is a further object of the invention to provide folded condenser tube with tube end-locking design for use in a motor vehicle, folded from a sheet material to form a multi-port tube.

It is also an object to provide a method to manufacture condenser tubes that provides for multi-port tubes with advantageous characteristics for automotive air conditioning applications. It is a further object to provide folded condenser tubes having very tight dimension tolerances, while at the same time maintaining long life for the 'roll' dies.

In addition, it is an object of the present invention to provide for a folded tube that is not an integrated part of the system before brazing, therefore, meeting the performance standards required while avoiding the problem of perfectly brazing folded tubes.

A further objective is to optimize the folded tube technology by reducing the tube wall thickness and at the same time to avoid the rigid relationship between total tube height and tube gauge, thus allowing more flexibility in tube design and optimization of material usage and reduction in cost.

In light of the above, there is a need in the art to provide a folded tube for a heat exchanger of a motor vehicle that achieves these objectives and desires.

SUMMARY OF THE INVENTION

The present invention solves a number of problems often found in extruded technology. Tight dimensional tolerances are achieved concurrent with achievement of long life spans for the roll dies used in the process. In its various embodiments, the present invention, therefore, provides cost benefits compared to extruded tubes. The present invention also provides surprising advantages inspite of the fact that in a preferred embodiment a folded tube is generally not an integrated part of the condenser prior to brazing.

Accordingly, the present invention is a multi-port folded tube for a heat exchanger, and, in particular, a condenser tube, with an improved tube locking

feature. In a preferred embodiment of the present invention, a multi-port folded tube is formed from material utilizing the manufacturing process as described hereinbelow wherein there is at least one tube locking feature. In preferred embodiments of the present invention, the folded tube comprises a tube with the at least one tube locking feature of the present invention, more preferably, the end tube locking feature.

The folded tube, and particularly, the multi-port heat exchanger tube, preferably comprises a base; a top spaced from and opposing said base; a first side interposed between said base and said top along one side thereof; a second side interposed between said base and said top along another side thereof; and each of said base and said top having at least one internal oriented portion; wherein the at least one top internal oriented portion abuts the at least one base internal oriented portion to define a plurality of fluid ports and wherein there is least one tube locking feature.

The folded tube in a preferred embodiment of the present invention includes a base, a top spaced from and opposing the base, a first side interposed between the base and the top along one side thereof, and a second side interposed between the base and the top along another side thereof. The folded tube also preferably includes at least one of the base and the top having at least one internal half web having an initial web width and an initial outside shoulder radius and capable of potentially being compressed when the at least one top half web is 'face to face' or 'aligned' with at least one base half web to 'abut' or 'contact' the at least one top internal half web with the at least one base internal half web and, defining upon closure, a tube with a plurality of fluid ports. The folded tube is then 'closed' or locked with the end locking feature as described herein below. Therefore, the present invention particularly relates to a multi-port folded tube for a heat exchanger, and, in preferred embodiments, a condenser tube wherein the folded tube of the present invention includes at least one of the base and the top from a generally planar sheet having at least one internal half web essentially aligned face to face and capable of potentially abutting when compressed, so

that when the at least one top internal half-web is 'face to face' or 'aligned' with at least one base internal half-web to abut the at least one top internal half web with the at least one base internal half web, closure provides a tube with a plurality of fluid ports. Also, preferred embodiments of the present invention have at least one 'tube locking' or 'closure' feature the tube locking or closure feature can be either at the tube end or other than at the tube end. Preferably, the at least one tube locking or closure feature is found at tube end.

Also, the present invention is a method of making a multi-port folded tube for a heat exchanger with at least one tube locking feature. The method includes the steps of providing a generally planar sheet, folding the sheet, and forming at least one internal half web having, preferentially, a first fold portion and a second fold portion. The method also includes the steps of aligning the at least one top internal half web and the at least one base internal half web to aide abutting of the two half webs. More preferably, the top half web and the base half web are face to face or directly aligned so as to provide effective multi-port formation. The method further includes the steps of folding the sheet and forming a base and a top opposing the base and a first side interposed between the top and the base and a second side interposed between the top and the base such that the at least one internal half web abuts or contacts either one of the top or the base other half internal webs to provide a plurality of fluid ports. The end of the tube is formed by having one sheet end of sheet is bent onto the another sheet end, and then the both locked ends are bent to form a tube end.

One advantage of the present invention is that a multi-port folded tube for a heat exchanger with such a locking feature can be used on with a variety of heat exchangers. In the case such as a condenser is provided for an air conditioning system of a motor vehicle for condensing liquid refrigerant. Another advantage of the present invention is that the folded tube is stamped and folded and is more economical to manufacture than an extruded tube. Yet another advantage of the present invention is that the folded tube has half webs that do

not extend the entire height of the ports to be formed, and, therefore, do not require compression to make a folded top or folded bottom tube portion alone that has to extend to the opposing top or bottom tube portion respectively. Still another advantage of the present invention is that a method of making the folded tube is provided whereby various tube-end locking features may be utilized. Yet a further advantage of the present invention, particularly in preferred embodiments, is that it provides a preformed end and support versus a 'traditional' closed end form that allows seams to be formed and held more closely together, thus eliminating the potential of multiple pin-hole sized 'gaps' at the end seams of the folded tube. Since the gap is relatively closed, brazing to a header slot, for example, becomes more efficient and the folded tube more desirable for these applications.

In preferred embodiments of the present invention, the folded tube may be an integrated part of the system before brazing or not an integrated part of the system before brazing. To avoid the problem of perfectly brazing folded tubes, a preferred embodiment of the present invention does not integrate the folded tube as part of the system prior to brazing.

Other features and advantages of the present invention will be readily appreciated, as the same becomes better understood after reading the subsequent description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1a is a perspective view of a partially closed folded tube;

FIG. 1b is a perspective view of the closed folded tube with the half walls abutting each other;

FIGS. 2 is a perspective view of a closed folded tube with the end folded;

FIGS. 3a is a perspective view of a closed folded tube according to the present invention, with the end half folded;

FIGS. 3b is a perspective view of a closed folded tube according to the present invention, with the a fully closed end;

FIGS. 4 is a perspective view of a closed folded tube according to the present invention, with tube locking feature found other than at the tube end;

FIGS. 5 is a perspective view of another closed folded tube according to the present invention, with tube locking feature found other than at the tube end;

FIG. 6 is an elevational view of a folded tube, in accordance with the present invention, illustrated in operational relationship with a heat exchanger of a motor vehicle;

FIG. 7 is a perspective view of a sheet utilized in a method of making folded tubes in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring to the drawings and particularly to FIG. 1a, 1b and FIG. 2 the basic process of tube folding in accordance with the present invention, and an embodiment of the subsequent tube 49 of the present invention is illustrated. A sheet material 70 is folded progressively into a muli-port 50 tube. The sheet 70 is folded to form several half-webs or internal half webs 40, 44, then bent into tube form. FIG 1b shows the half web from the top surface 40 and the half webs from the base surface 44 face-to-face and abutting one another at point 51, together forming webs separating multi-ports.

Referring to FIG. 2, at one end of the sheet ends 34 and 32, are bent twice inwardly on one end 34 yielding three layers and bent once on end 32 yielding 2 layers, together forming a 5-layer locked tube end 35, yielding specific relations between tube height and sheet gauge.

Referring to FIGs. 3a and 3b, the tube locking features 135,235 are formed. In FIG. 3a, one end 132 of the sheet is bent onto the other end 134 of the sheet 70. Subsequently end 132 and end 134 form locked end 135 that are bent to form the tube end 235 of Fig 3b. The two locked sheet ends form another end of the multi-port tube. The end of the tube is formed by having one sheet end of sheet is bent onto the another sheet end, and then the both locked ends are bent to form a tube end.

Referring to FIG.4, the tube-locking feature 150 is not at tube end 350. Tube locking feature 150 is found, preferably, at the top of a middle port 351 of the folded tube 350.

FIG. 5 shows another preferred embodiment of the present invention. The tube-locking feature 250, as in FIG 4, is not found at tube end. Preferably, the tube-locking feature 250 is found on the inside tubes 451 yielding a clearance between the two sheet ends (delta) which does not depend on the sheet width.

Referring to the drawings and in particular FIG. 6, one embodiment of a heat exchanger 10, according to the present invention, such as a condenser for an air conditioning system (not shown), is shown for a motor vehicle (not shown). The heat exchanger 10 includes a plurality of generally parallel folded tubes 49, according to the present invention, extending between oppositely disposed headers 14, 16. The heat exchanger 10 includes a fluid inlet 18 for conducting cooling fluid into the heat exchanger 10 formed in the header 14 and an outlet 20 for directing cooling fluid out the heat exchanger 10 formed in the header 16. The heat exchanger 10 also includes a plurality of convoluted or serpentine fins 22

attached to an exterior of each of the tubes 12. The fins 22 are disposed between each of the tubes 12. The fins 22 conduct heat away from the tubes 12 while providing additional surface area for convective heat transfer by air flowing over the heat exchanger 10. It should be appreciated that, except for the folded tube 12, the heat exchanger 10 is conventional and known in the art. It should also be appreciated that the folded tube 12 could be used for heat exchangers in other applications besides motor vehicles.

Referring to FIGS. 7a, 7b and 7c, and FIGs. 1 and 2, a method, according to the present invention, of the making the folded tube 49 is shown. The method includes the steps of providing a generally planar sheet 70 of elongate, deformable material coated with a braze material forming the base 24 and top 26 having their respective ends 32 and 34 edges along a longitudinal length thereof as illustrated in FIG. 7A. The ends 32 and 34 of the base 24 and top 26 can be either flat or arcuate as illustrated in FIGS. 1a, 2, 3a and 3b. Alternatively, for the folded tube 49, 249, 349 and 449, the ends can be formed as illustrated in FIGS. 3a through 5. The method includes the step of folding the sheet 70 from the lateral sides to initially form the internal half webs 40 on the top with the second internal half web 44 on the base to an initial predetermined web height and width as illustrated in FIG. 7B. The method also includes the step of aligning the internal half webs 40, 44 approximately face to face so that they may abut each other. The method includes the step of folding the ends 32 and 34 toward one another until they meet to form ports 50 as illustrated in FIGs. 1b and 2. The method includes the step of connecting the ends 32 and 34 together. The method includes the step of brazing the folded tube 49 by heating the folded tube 49 to a predetermined temperature to melt the brazing material to braze the ends 32 and 34 and the internal top half webs 40 to the base half webs 44. The folded tube 49 is then cooled to solidify the molten braze material to secure the ends 32 and 34 together and the internal top half webs 40 and the base half webs 44 together. It should be appreciated that, instead of the ends 32 and 34, the partition 150,250 of the folded tube 349,449 may be formed internally as in

Figures 4 and 5. Accordingly, the folded tube is a cost reduction over current tubes. The folded tube has internal half webs that are folded and potentially 'squeezed' to maintain a predetermined distance between the top and base 24. The folded tube also has the internal half webs forming ports with a defined hydraulic diameter.

Preferred embodiments of the present invention, as described above, and in particular, as exemplified in FIG. 4, and 5 therefore result in use of less material for tube production, increased refrigerant cross sectional area availability, and, therefore, less internal pressure restriction for the air conditioning system. In one preferred embodiment of the present invention, the folded tube is a tube having a locking feature supported with a 'T' shaped wall 150 such that the end edges would be in the tube's interior side to maintain an approximately flat wall. In another preferred embodiment, the locking feature is contained within a 'U' shaped interior wall 451. Preferably, the 'U' shaped interior wall is 'doubled' such that the perpendicular end wall portions or edges would be between the tube's interior walls to maintain closed flat end wall. More preferred would be 'U' shaped walls wherein is doubled

In a preferred method of the present invention, referring to FIG. 3a the planar sheet is shaped such that the width across the tube formed therefrom is greater than the height of the tube, and the edges of the planar sheet have a locking feature 135 In the form of a 'J'.

The present invention has been described in an illustrative manner. It is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation.

Many modifications and variations of the present invention are possible in light of the above teachings. Therefore, within the scope of the appended claims, the present invention may be practiced other than as specifically described.